UNIVERSITY OF BATH

HubNet
The Supergen Energy Networks Hub

RISK Day
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Impact of the Stochastic Behaviour of Renewable Resources on Power System Reliability

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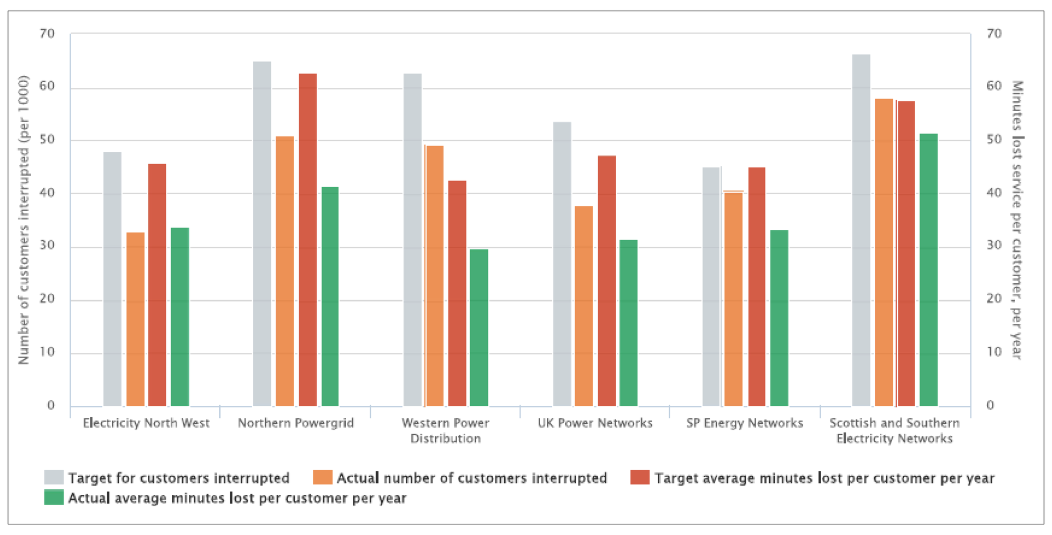
Challenges of Network Operation

- Strict targets set by **Security and Quality of Supply** (SQS) regulation.
- **Integration of renewables** into conventional distribution networks introduces **uncertainty** about their impact on **reliability performance**.
- Planning, operational and commercial implications.



UK DNOs' Annual Reliability: CI and CML Indices

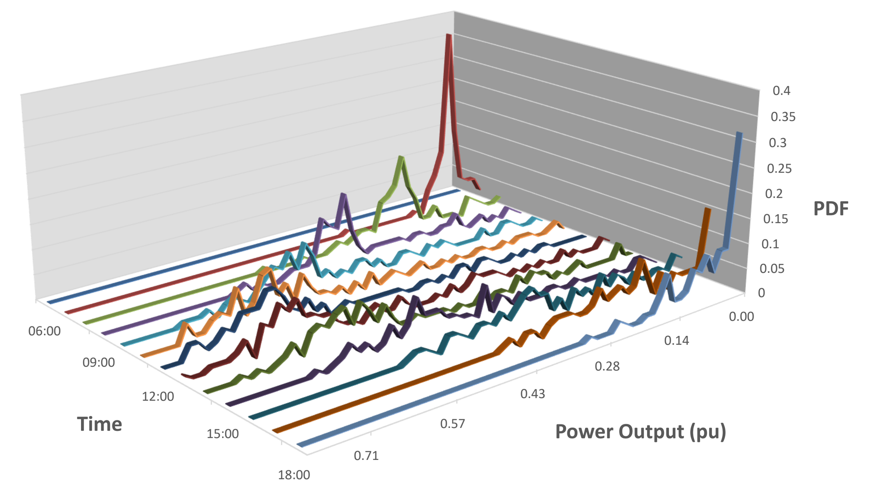
Class of Supply	Range of Group Demand (GD)	Minimum demand to be met after first circuit outage
A	GD ≤ 1 MW	In repair time: GD
B	1 MW < GD ≤ 12 MW	(a) Within 3 h: GD - 1 MW
		(b) In repair time: GD
C	12 MW < GD ≤ 60 MW	(a) Within 15 min: min GD - 12 MW; 2/3 GD
		(b) Within 3 h: GD
D	60 MW < GD ≤ 300 MW	(a) Immediately: GD - up to 20 MW
		(b) Within 3 h: GD
E	300 MW < GD ≤ 1500 MW	Immediately: GD
F	GD > 1500 MW	According to transmission license security standard

P2/6 Security of Supply Requirements

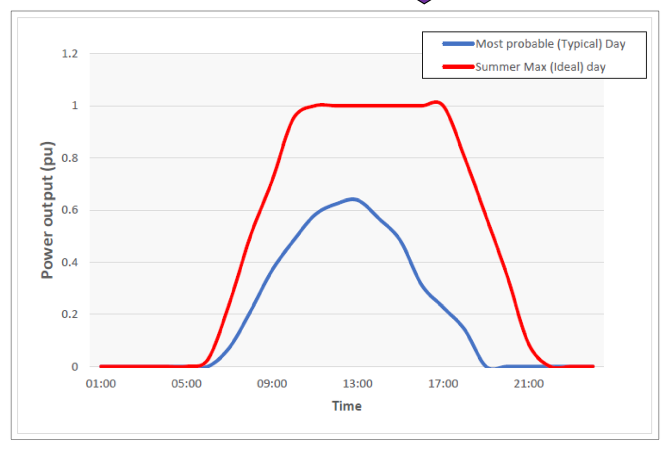
Variability of Renewables

Renewable Energy Resources (RERs) characteristically vary both **spatially** and **temporally**.

Modelling the **Clouding effect** → Filtering the raw data → Most probable solar output



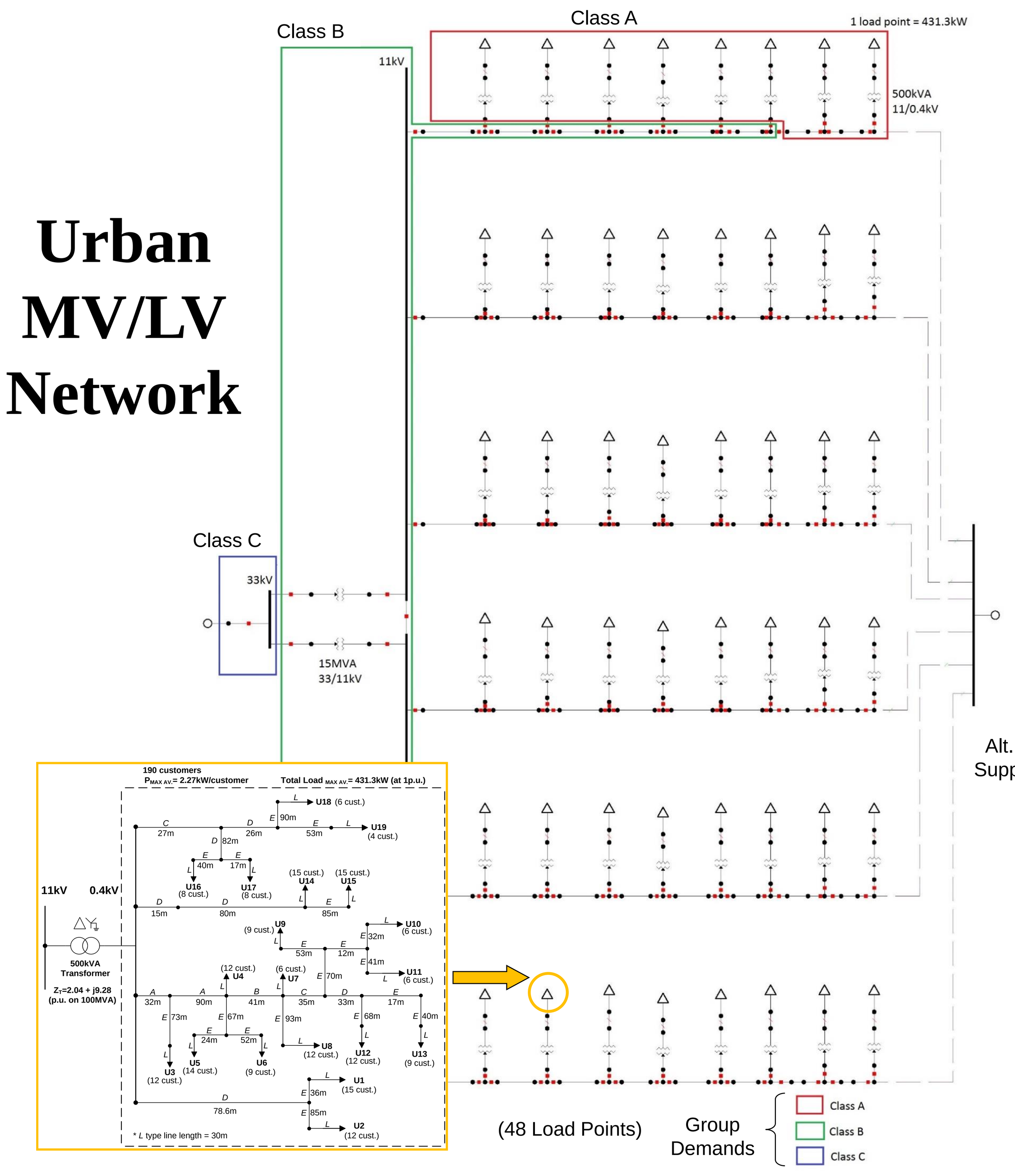
Probability of solar power output variation



Daily solar PV output

Impact of clouding on models used for network reliability assessment ?

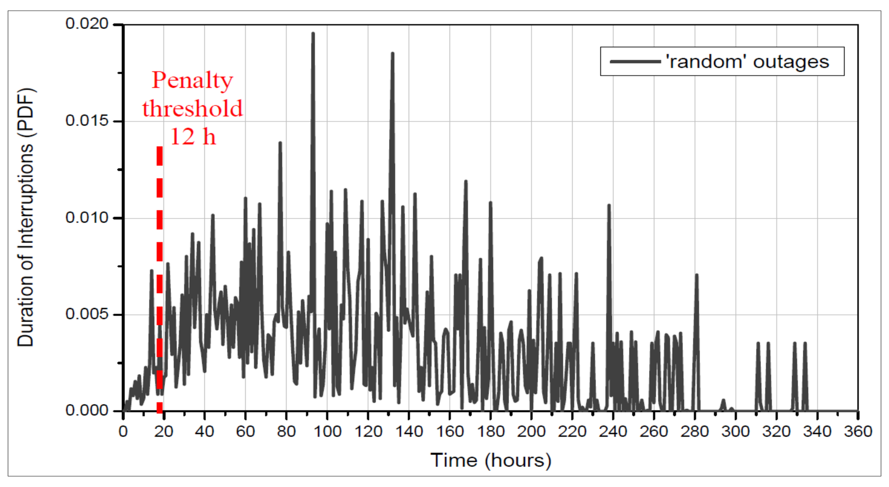
Urban MV/LV Network



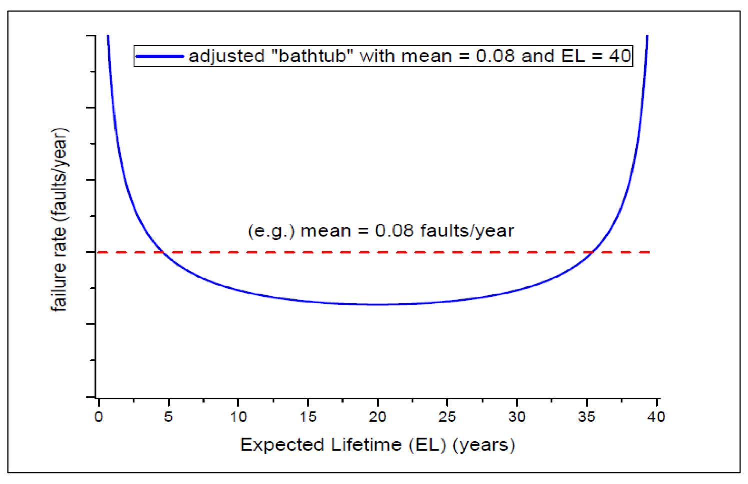
- After Diversity Max. Demand: 2.27kW/customer
- LV aggregate networks with reliability equivalents
- Network divided in group demand classes

Integrated Quality of Supply Analysis

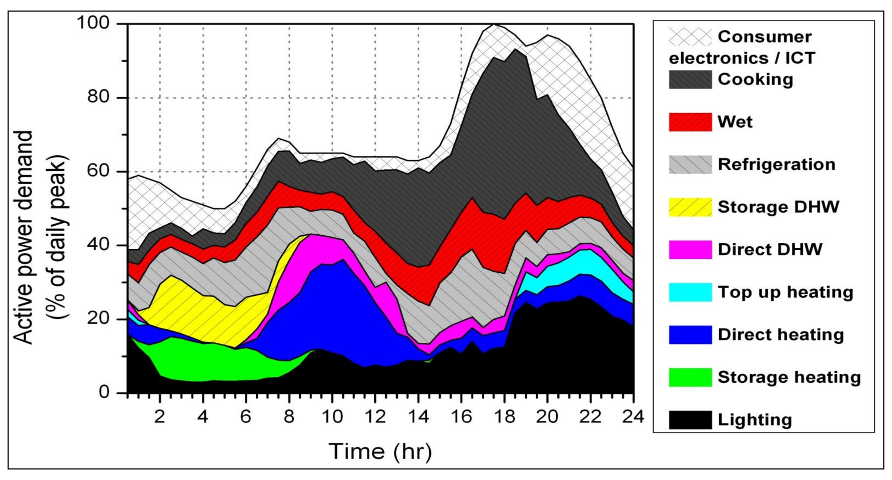
Conventional **Monte-Carlo simulation** improved by including:



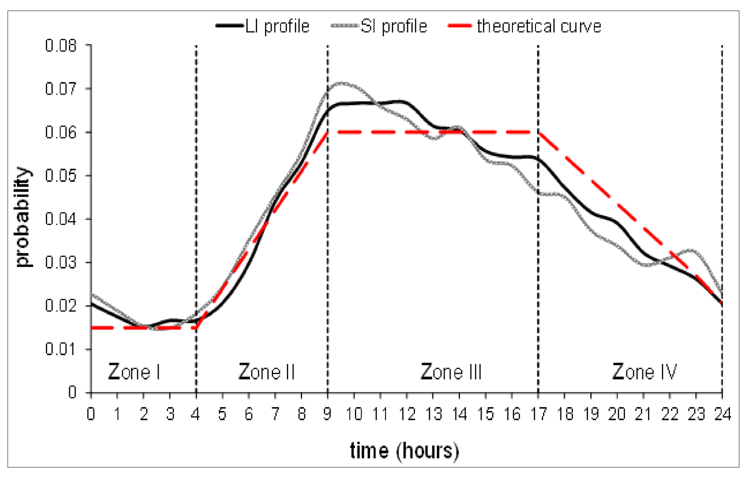
Extent of variation: Sustained (long) interruptions



Failure Rates: Bathtub distribution modelling



Typical UK daily demand (Winter day)



Daily probability of Long/Short Interruptions

Smart Interventions

1) Demand-side Response (DSR) for reliability improvement: demand reductions during periods with high fault-probability.

2) Uncontrolled **Solar Photovoltaic (PV)** energy with a 50% overall network penetration.

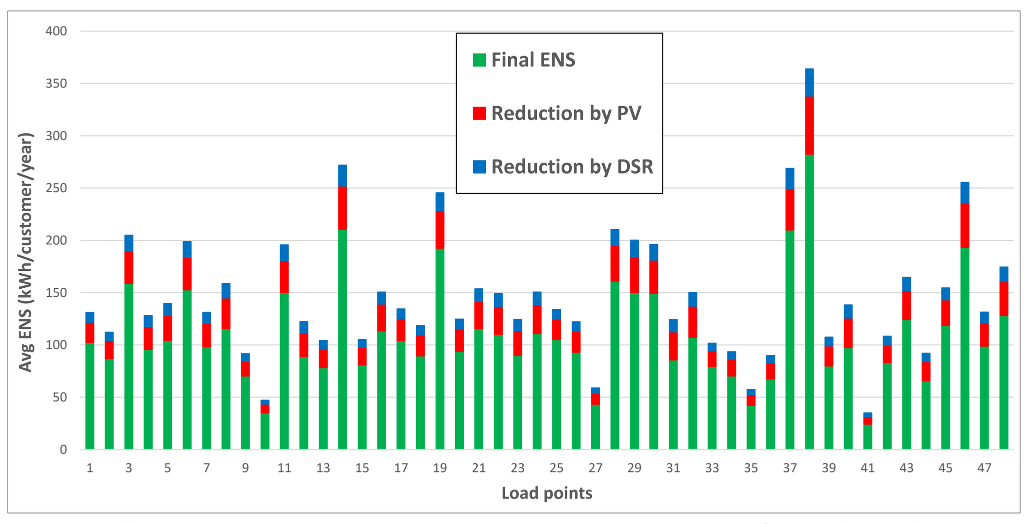
3) PV+DSR – to take advantage of period with highest likelihood of fault occurrence.

4) Energy Storage (ES) where daily Microgeneration (MG) output is stored during the day to provide a backup capability of 3.67 kWh per customer per fault.

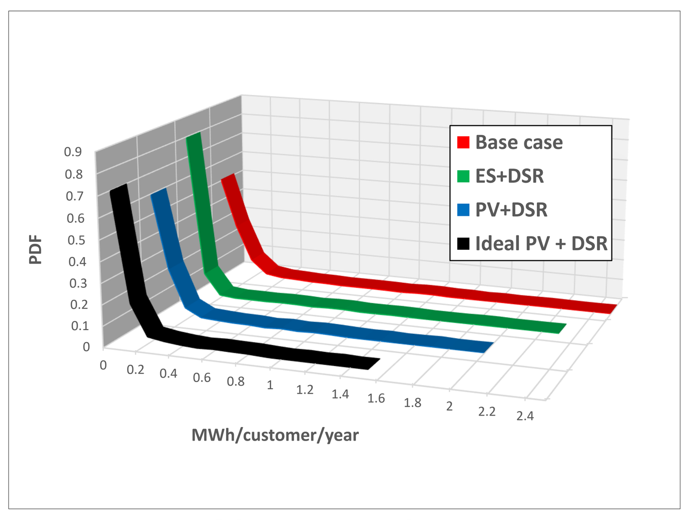
5) ES + DSR – to illustrate and quantify the value of MG control.

- **Reduction** in ENS, SAIDI and average interruption duration.
- **Accurate** reliability performance assessment for distribution network **planning** and **operation**.
- **Economic** benefits to **DNOs** through OFGEM penalty/reward schemes, and to **customers** through reductions in electricity bills and improved quality of supply.

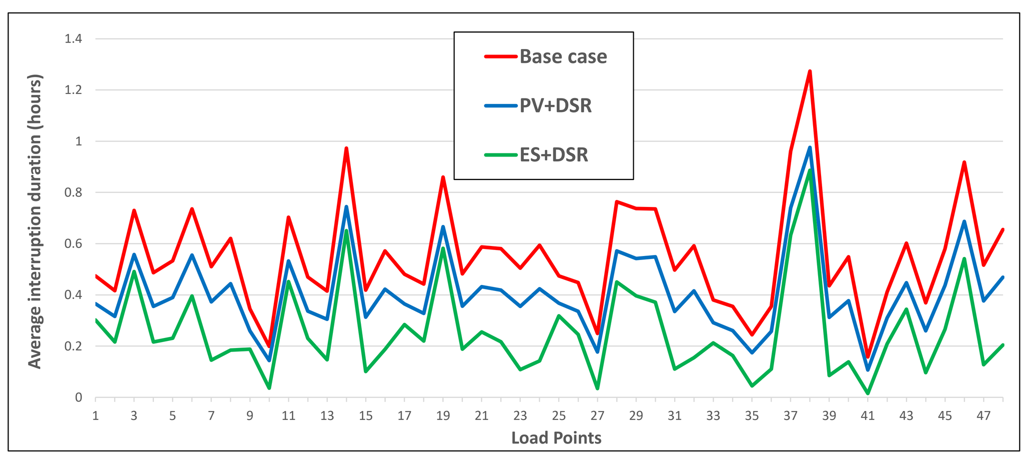
Risk Quantification



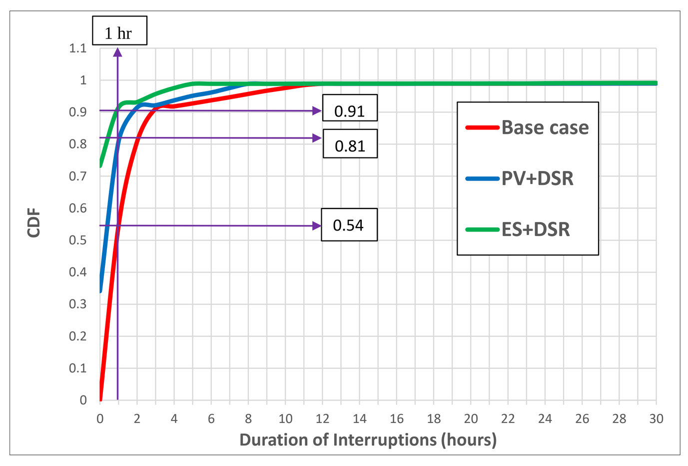
Effect of PV and DSR on ENS per load point



Impact of interventions on ENS



Average outage duration per load point



Impact on duration of interruptions

Scenario	Average (kWh)	Reduction from base case
Base case	146.37	-
DSR	135.11	7.7%
PV	121.90	16.7%
PV+DSR	110.63	24.4%
ES	85.09	41.9%
ES+DSR	78.18	46.6%
Ideal PV	89.42	38.9%
Ideal PV+DSR	78.20	46.6%

ENS Index

Impact of clouding effect

Scenario	Average (kWh)	Reduction from base case
PV	121.90	16.7%
Ideal PV	89.42	38.9%

Over-estimation of **22.2%**

Scenario	Hours/customer/year	Reduction from base case
Base case	0.55	-
PV	0.45	17.7%
PV+DSR	0.41	26.0%
ES	0.28	49.0%
ES+DSR	0.26	53.3%

SAIDI Index

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